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ABSTRACT

Significant findings of the comprehensive evaluation of a computer-based curriculum in the basic medical sciences using the PLATO IV computer system are presented. The study was conducted by the Office of Curriculum and Evaluation (OCE) of the School of Basic Medical Sciences (SBMS) at the University of Illinois, Urbana/Champaign (UC). It was designed to assess the progress of the project relative to goals outlined in the contract; provide feedback to the Project and School personnel, as well as to the funding agent; and portray the Project as it had evolved since its inception. The techniques of responsive evaluation and portrayal were used combined with Context, Input, Process, Product (CIPP) and discrepancy evaluation. Significant results of the evaluation are reported under the headings: summary of data, major factors which impacted upon project functioning, project accomplishments, recommendations, and unresolved issues. Eight recommendations cover a variety of aspects including qualifications of staff, on-the-job training programs, and the need for a 6-12 month funded planning and recruitment phase. They provide insight into the diversity of factors that interact to influence the successful development and implementation of an educational program. (VT)

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EVALUATION OF A THREE YEAR HEALTH SCIENCES PLATO IV COMPUTER-BASED EDUCATION PROJECT

by

William E. Sorlie
and
Diane L. Essex

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Evaluation of a Three Year Health Sciences PLATO IV Computer-Based Education Project

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Introduction

During the period (July, 1973 - July, 1976), efforts were undertaken at the School of Basic Medical Sciences (SBMS), Urbana-Champaign (UC), University of Illinois College of Medicine to develop a computer-based curriculum in the basic medical sciences by using the PLATO IV computer system. These development efforts were supported, in part, by a Department of Health, Education and Welfare, Bureau of Health Manpower contract (No. 1-PE-34-68). The contract, entitled "PLATO IV Applications in the Basic Medical Science," was for three years. Pursuant to this contract, a comprehensive evaluation of the Project was conducted. The Office of Curriculum and Evaluation (OCE), School of Basic Medical Sciences-UC was contracted in July of 1975 to develop and conduct this evaluation. The goal of this paper is to present the significant findings of the comprehensive (112 pages) evaluation conducted by OCE.

Background

The School of Basic Medical Sciences at Urbana-Champaign has been involved in an innovative educational approach to the preclinical year(s) of medical education. When SBMS-UC opened in the Fall of 1971, basic science faculty and local practicing physicians prepared a basic medical sciences curriculum to provide medical students with the skills and knowledge necessary to allow entry into a clinical training program after 10 months of study. The curriculum contained 12 basic medical science disciplines and was organized into a five volume document. The curriculum contained over 400 self-instructional units and incorporated over 4,000 specific learning objectives. Each curriculum unit included all necessary components to allow the student to proceed at his/her own rate of progress and in a manner consistent with his/her own learning style.

In addition, to demonstrate the relevance of basic science to clinical medicine, each of the 400 learning units was related to one of 10 clinical problems or diseases. While studying the learning units, each student is provided multiple opportunities to interact with local practicing physicians and their patients. These interactions serve to facilitate the correlation of the basic science content and clinical problems or diseases. The specific patient problem is used as the entry point into interdisciplinary principles of basic science germane to the understanding of medicine as a whole.

The SBMS-UC program relies heavily on its 25 full-time-equivalent (FTE) basic science faculty members to assist students in acquiring knowledge/skills in the 12 basic science disciplines. Each faculty member carries joint responsibilities with the medical school and with a corresponding appropriate

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* Reprints may be requested from, Office of Curriculum and Evaluation, Room 255, Medical Sciences Building, University of Illinois, Urbana, Illinois, 61801.

department on the Urbana-Champaign campus. The full-time SBMS-UC faculty are responsible primarily for preparing and revising the curriculum document. They also present lectures, laboratory exercises, and demonstrations for the students. Faculty also advise medical students throughout the year.

Student progress in the SBMS-UC program is assessed by three methods: (1) self-testing by the students via pre- and post-test questions (Levels I and II) in each learning unit; (2) objective, cognitive assessment with a comprehensive diagnostic examination (Level III) given after each of the curriculum divisions (clinical problems); and (3) an oral examination, given by a physician, (Level IV) in which the students' ability to relate the basic sciences to each clinical problem is tested.

An interesting feature of the Level III assessment is that it is administered to students via PLATO IV. Since 1972, computers have been used by the School to implement the Level III method. This medium was and is currently being used to complement the self-paced, individually-guided educational program.

SBMS-UC PLATO IV Proposal

To complement and add support to the existing SBMS-UC educational program, administrators at the School, in 1973, sought and received monies from HEW to develop and implement the Computer-Based Education Project (CBEP). Some of the more important features of the initial proposal and ensuing three year HEW contract were:

1. A core curriculum of approximately 300 PLATO IV computer units was to be developed.

2. The materials developed by the CBEP were to cover the same general scope as the SBMS-UC curriculum.

3. Developed computer lessons were to include learning objectives, self-testing, and evaluation devises.

4. A modular format was to be developed that would allow for multiple entry and exit points within each module that would permit students with different training levels equal access to the same materials.

5. Computer lessons were to be developed to meet the specific needs of disadvantaged students.

6. The computer lessons were to be designed so they could be exportable to other institutions without major changes.

The Project staff was to be primarily full-time, in recognition of the intensive effort anticipated for the adaptation of the new teaching system to health sciences.

> "The composition of the staff was to include basic scientists with advanced degrees who were to work closely with physician contributors to maintain a clinical orientation in the developed lessons.

Each basic scientist was expected to learn enough of the fundamentals of the programming language to be fully conversant with the system's capabilities and limitations. In practice this would mean that the basic scientists "content specialists" would program a portion of their own materials. In order to use their time more efficiently, they were to be assisted by programmers for the bulk of the actual "encoding" tasks and by programming consultants to maintain a sophisticated level of machine function. While they would not have regular conventional teaching duties, the content specialists were to be closely linked with the regular SBMS-UC campus teaching faculty."[1]

The Health Sciences Network

It is important to note that during the first year of CBEP an additional task of enormous scope was undertaken by the Project. This task was the attempted development of a national "authoring and use" PLATO health science network.

The rationale and definition of this network are stated by the Projects' director as

> ". . . it was already clear that the needs for a large body of lesson material could not be completely handled at a single institution, even with the assistance of the special faculty group and support staff that was funded under contract. It also seemed evident that interinstitutional participation would lead to a broader perspective of needs and more approaches to fulfilling them. A more diverse cadre of students could react to the educational material created. These were all seen as distinct advantages. It was recognized that wider participation might well lead to more diffuseness of educational objectives, by attempting to tailor the lessons to the differently perceived needs of varying institutions. Also, there would be additional costs in terms of training authors at remote sites, communication costs between outlying institutions and Urbana, Illinois, and, not the least important, the considerable overhead in faculty time in planning and administering such an informal consortium. However, it was felt that the advantages clearly outweighted the problems, and beginning in 1974, PLATO terminals were loaned by the University of Illinois to a number of other medical schools that agreed to undertake the authoring of lessons and to give their students access to the developing library of health sciences lessons. Outside participants paid a share of the PLATO service costs as well as the actual communications costs. Since 1974, seven institutions have participated in this effort in an organized fashion.[2]

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[1] Hody, G. L., Levy, A. H. "PLATO IV Applications in the Basic Medical Sciences - Part I, May 1976, pp.

[2] Levy, A. H., "An Interim Report, Computer-Based Education: Processes and Potentials, July 1976, p. 4.

Methodology

The evaluation was designed to assess the progress of the Project relative to the goals outlined in the contract (summative evaluation), provide feedback to the Project and School personnel, as well as to the funding agent (summative and formative evaluation), and portray the Project as it had evolved since its inception. Secondary to these goals, it was the desire of the evaluators to provide information to a diverse audience interested in innovation in medical education and development of computer-assisted instruction.

The techniques of responsive evaluation and portrayal (Stake, 1972, 1974) were used to portray the Project as it had evolved during its existence. The methods of Stufflebeam (1971) -- CIPP -- and Provus (1972) -- Discrepancy Evaluation -- were employed to assess the Project's accomplishments, to provide information for decision-making to the funding agent and School personnel, and to examine the contributions of the Project to computer-assisted instruction and innovation in medical education. Information from the portrayal was also useful in evaluating all aspects of the Project's functioning. The portrayal also served to provide formative feedback to Project personnel.

As a first step in the evaluation, the objectives of the contract were outlined. Three major objectives were identified: development of course teaching material, implementation of the course material, and effectiveness of the course materials. These objectives were then delineated into small (sub) objectives which could be measured more easily. For each (sub) objective, the evaluation questions were identified, data sources specified, and analysis strategies outlined. Data were gathered from varied sources. Interviews were conducted with teaching faculty at SBMS-UC, allied health professionals, the Dean of the School, past and present Project directors, and Project authors. Opinions about the courseware were also obtained from medical students and site directors via questionnaire.

In order to evaluate quantitatively lesson effectiveness, lesson usage and performance data were examined. In the first group of analyses, lesson usage and performance of Urbana students on relevant portions of Urbana diagnostic examinations (Level IIIs) were analyzed. Means and standard deviations were calculated. A *t*-test was used to examine performance of "users" and "nonusers." Because the correlation between the discriminant function and performance was essentially zero, *t*-tests for the difference between two means were favored over an analysis of covariance with the discriminant function as a covariate. The discriminant function is a weighted composite of incoming ability measures such as MCAT scores and undergraduate grade-point average. It has been used by the College of Medicine in the admissions process and has been shown to correlate most highly with performance in the first year of medical school.

In the second major analysis, lesson usage and performance on appropriate segments of a college-constructed certifying examination were analyzed for students enrolled at Urbana and Chicago. Since a significant correlation was observed between the discriminant function and performance on the examination, a two-way analysis of covariance with the discriminant function as the covariate was used. In this analysis, performance on an appropriate segment of the June College Certifying Exam was the dependent variable; usage of lessons and educational program membership were the independent variables.

Analysis of Urbana Student PLATO Lesson Usage and Examination Performance

PLATO lessons were grouped according to their applicability to content tested in specific sections of the SBMS-UC diagnostic examinations (Level IIIs). The groupings were determined by the assignment of lessons to basic science curriculum units and by the assignment of these units to clinical problems within the SBMS-UC curriculum. Each Level III examination tests a student's knowledge of the basic sciences as specified by curriculum units within a curriculum module called a clinical problem. Judgments about the association of PLATO lessons with curriculum units were made by Project authors. The mapping of lessons to units was provided to students in an on-line catalogue at the beginning of the academic year.

Since not all clinical problems had associated with them a moderate number of basic science lessons, it was decided that only select portions of the clinical problems would be considered. Selection of appropriate segments was based on the number of lessons associated with the particular segment. Additionally, since students are not required to take Level III examinations, performance was analyzed on only those exams completed by a reasonable number of students. Nearly all students take the first several Level IIIs, and fewer students take the exams near the end of the academic year. However, in terms of the relationship between curriculum units and basic science lessons, a limited number of lessons existed (in 1975-76) which were associated with material learned in the latter portion of the year.

After the above factors were considered, 17 groups of lessons relating to portions of the SBMS-UC curriculum were identified. However, since no individualized lesson usage data existed until mid-October, performance on the first two clinical problems and its relationship to usage of the PLATO lessons could not be examined. This constraint reduced from 17 to 12 the number of areas in which lesson effectiveness could be scrutinized.

With assistance from Project authors, it was also possible to associate lessons with some portions of a college-constructed certifying examination (Freshman Comprehensive). The 62 PLATO lessons applicable to four specific areas contained in this exam were analyzed.

Summary of Data

Based on the 12 analyses conducted data from only one analysis (Microbiology of Peptic Ulcer) revealed significant performance differences favoring the user group. In the remaining analyses, it was generally observed that although some performance benefits accrued to users of the lessons, differences between users and nonusers were not significant. In addition, no performance benefits were found to exist for students who had used PLATO lessons related to subtests on the College Freshman Comprehensive.

For 1976-77 the procedures described above (except for the Freshman Comprehensive) were duplicated. Of 19 analyses performed, three (Anatomy, Pharmacology twice) demonstrated significant differences favoring users and one (Microbiology) demonstrated a significant difference favoring nonusers. All remaining analyses showed no significant differences.

Accomplishment of Contract Objectives

Due to space limitations, the specific text for this section has been deleted. The text is available from the author on request.

Major Factors Which Impacted Upon Project Functioning

A number of factors impacted upon the Project and affected its ability to attain many of the contract objectives. Some of these factors, such as the ECS crisis, were outside of the control of Project management. Additionally, even with careful planning, it would not have been possible to anticipate the consequences of these events. It is also important to note that the PLATO IV system was itself in an experimental stage of development when the Project was begun. For example, the TUTOR language was evolving rapidly. The fluidity of the language created problems when Project staff and management attempted to develop and implement programming standards to which lessons must comply. Other aspects of the Project's functioning, such as defining realistic objectives, hiring staff, implementing effective lesson development and review procedures, and establishing liaison relationships with personnel external to the Project, should have been within the control of Project staff and management.

Relative to factors which affected the Project, one of the major ones was the contract itself. Since Project staff did not participate in the formulation of the contract, it is suggested by the evaluators that this factor was largely beyond the control of Project staff and management. The scope of the contract outlined objectives which were somewhat unrealistic given the resources requested and awarded and the short three-year time frame agreed upon for the accomplishment of objectives. For example, monies existed for only five full-time equivalent (FTE) authors (four were ultimately hired) who were expected to develop lessons to cover the greater portion of the SBMS-UC curriculum which contained 12 basic science disciplines. Project management and staff recognized the enormity of their task. Yet, at the same time, no systematic and clearly defined operational plan of action was implemented to allow them to approach their task in a directed manner. The total complement of four authors was not available for full-time participation until approximately one year after contract monies were awarded in July of 1973. The recruitment of qualified staff was expected to occur in July and August of 1973. However, by that time, most competent individuals had secured positions for the next academic year. Thus, one year of the Project's three-year tenure was spent without a full authoring staff.

After the Project was staffed, authors generally worked without the benefit of guidance in the selection of topics for lesson development. Authors spent considerable time during the life of the Project developing such procedures. Authors indicated that because of the absence of a clearly defined plan of action, the Project shifted directions on many occasions. As the Project shifted directions, author responsibilities changed and, as a direct result, it was difficult to maintain sustained efforts in lesson production. Further, authors carried out their instructional duties without the sustained participation of a full-time educational/instructional design specialist.

When Project administration recognized the improbability of meeting contract objectives, the scope of the Project was expanded to encompass the development of a multinodal network. It was hoped that participation of

faculty at other institutions would lead to the development of a larger body of lesson material to which a diverse cadre of students could react. It was also decided by Project management that the Kansas pharmacology materials would be translated to PLATO IV. Authors felt that these expansions of the contract required time and effort which could have been devoted to their production of basic science lessons. Yet, two of the major accomplishments of the Project were the establishment of the network and the translation of the Kansas materials.

Having to provide on-the-job training was also a major factor which impacted upon the overall productivity of the Project. No formal training programs in the TUTOR language were offered by the developers of the PLATO IV system. Consequently, training programs within the Project had to be developed, but these were found lacking in that authors felt a need for more in-depth training in the TUTOR language, programming, and instructional design. Contrary to popular belief at that time, the TUTOR language was found difficult to understand and use proficiently. Authors spent most of the second year of the contract learning and improving their skills in TUTOR and basic instructional design. Unfortunately, this necessary year of on-the-job learning was not planned for in the contract.

Another important factor which affected the Project's successful implementation was its difficulty in establishing effective liaison relationships with faculty at the School, allied health professionals, faculty external to the School, and students. To produce lessons which would conform to specifications within the contract, authors should have had input from these individuals during the lesson selection, development, and review process. Further, because faculty at the School participated only minimally in these activities, they would not recommend lessons to students and few references were made to the lessons in the School curriculum. Because of the absence of strong liaison relationships with School faculty, the Project had throughout its tenure a truly adjunct status and was, for the most part, peripheral to the educational process within the School. It is not clear whose responsibility it was to establish more satisfactory liaison relationships, but without them, the Project and its lessons were not integral parts of the School's instructional process.

Project Accomplishments

When Project accomplishments as they related to the specific contract objectives were reviewed, it was seen that no one objective was achieved completely. Many factors affected the Project's functioning and impacted negatively on the production of lessons. However, if Project functioning is considered on a macro level with less emphasis on the specific contract objectives, a number of contributions can be identified. These contributions are described briefly in the following paragraphs.

One of the Project's major accomplishments was that it demonstrated that PLATO IV was a usable and viable instructional system in the basic medical sciences. For example, student users at SBMS-UC felt that Project-authored lessons were good supplements to the basic science curriculum. Students indicated that lessons helped them learn basic science concepts. They also requested that additional lessons be developed. Further, it was generally observed that some higher level of performance on examinations was achieved by lesson users as compared to that of nonusers. These differences, though for the most part, were not significant.

The Project also demonstrated that many features of the PLATO IV computer system could be utilized effectively as a learning medium. Most of the courseware that was developed did, in some way, capitalize on the interactive, innovative capabilities of PLATO IV. For example, students indicated that they especially liked interactive lessons and lessons which graphically simulated complex biochemical reactions. Additionally, with the conversion of the Kansas pharmacology materials, the Project exhibited that PLATO IV was an excellent host for lessons developed on another computer system. Based on the estimates of one Project director, the Kansas materials were converted to PLATO at 10-20% the cost of creating lessons de novo. Further, there are some indications that the converted courseware ran more effectively on PLATO than it did on its parent system.

Another major contribution of the Project was the role it played in the dissemination of information about PLATO IV to the CAI health science community. When the Project began in 1973, little was known nationally about PLATO IV. At that time, the prevalent attitude was that the system was expensive, as well as difficult to use and understand. However, partly through the efforts and demonstrations made by Project personnel at national meetings and conferences, the PLATO IV system is now a sought after commodity.

After it became apparent that the goals outlined in the contract could not be accomplished within the specified time frame, the concept of the multinodal PLATO IV health sciences network was born. It was thought that if a number of institutions became involved in the development of lessons, the original scope of the contract might be achieved. With the addition of network sites, more content expertise would also become available. If other faculties were to become involved in initial lesson production, then the exportability of lessons might also be facilitated. The evaluators believe that the Project's plan of having network sites participate in the initial development and use of courseware was a novel and exciting idea. Potentially the inter-network lesson development process could help solve one problem which exists currently on most other CAI networks--that lessons cannot be of any instructional value or possible use unless they have been produced at the home institution. Unfortunately, not enough monies, personnel, and time were available for the full implementation of the networking concept.

In summary, the Project did contribute to the available body of PLATO IV courseware and was successful in demonstrating that the system was viable for computer-assisted instruction. The multinodal network concept was a good strategy, and some of the Project's lesson development-procedures and systems could be used elsewhere.

Recommendations

The primary purpose of this section is to provide recommendations which may be useful to individuals considering or planning the development of a project similar to the Computer-based Education Project. The recommendations cover a variety of aspects ranging from qualifications of staff, on-the-job training programs, and the need for a 6-12 month funded planning and recruitment phase. Data from diverse participants, such as Project directors and authors, and experiences of the evaluators relative to program development shaped the formulation of these recommendations. It is hoped that the reader will gain insight into the diversity of factors that interact to influence the successful development and implementation of an educational program.

Recommendation 1: A minimum of a 6-12 month funded planning and recruitment phase is critical to the successful development of the Project.

To expect a complex CAI project to be fully functioning immediately after the contract has been approved and funded is unrealistic. A period of time for operational planning and staff recruitment is necessary. During this planning period, operational goals should be defined, a plan of action for achievement of goals should be developed, time frames for the accomplishment of objectives should be estimated, and Project staff should be recruited and hired. Training programs should be developed and should include training in the programming language, basic instructional design, and fundamental instructional concepts. Intensive programming training should be developed for those individuals who will computerize lesson designs.

During this funded planning and recruitment phase, the basic design of lesson development and review procedures should be outlined. The existence of well-designed procedures will guide authors in their lesson development activities and will reduce the length of the interval between when authors join the Project and when they can produce lessons which meet the specifications contained in the contract. Additionally, if lessons are to respond to the needs of various user groups, input from the physician community, basic scientists external to the Project, allied health professionals, and student users should occur during the selection, development, and review of lessons. Thus, the foundations for effective liaison relationships between Project staff and other groups should be built before staff joins the Project.

Recommendation 2: In order to encourage optimal Project functioning, the Project should be developed and implemented in such a way that it is an integral and meaningful part of the School's educational process.

As observed with the Computer-based Education Project, the adjunct status of the Project contributed negatively to its functioning. It appears now that the adjunct arrangement contributed to many problems, including the unwillingness of School faculty to recommend lessons to students or reference lessons in the curriculum document. If a project is to succeed and if its lessons are to be used substantially, then the project must be recognized academically and its authors must be viewed as productive professionals. Further, nonproject basic scientists within the School should participate in the selection of topics for lesson development. If these interactions are to occur, then formal liaison relationships must be implemented. The existence of mechanisms to facilitate interactions is essential if faculty are to aid authors in identifying basic science deficiencies of students and if the lessons are to become an integral part of the instructional process.

Of all the suggestions offered, that of incorporating the Project into the educational process is by far the most difficult in terms of recommending actual functional arrangements to accomplish the goal. It has been suggested that academic departments hire and control authoring personnel. Within the department, the author would be required to produce instructional materials (lessons). Evaluation of authors would be based on the instructional merit of lessons with rewards and promotions contingent primarily upon the production of high quality lessons. Productive authors would receive the same respect and rewards given currently to productive researchers.

Other individuals have recommended that Project authors hold joint appointments in departments, but that the academic department would only participate in the recruitment of the author and would not control his/her lesson development activities. Authors stated that some bench research and classroom instruction (perhaps as much as 20-30% of their appointment) should be part of their responsibilities and that these activities should be carried out within the context of a department. They felt that research would allow them to remain abreast of developments in their field. Instructional duties would keep them attuned to student needs, and thus, facilitate lesson development. Authors would be rewarded primarily for excellence in lesson production.

Both of the recommendations outlined above require acceptance of and commitment to the concept of differentiated staffing with equivalent promotions, stature, and rewards given for either instructional or research contributions. At present, within this University, professionals are promoted primarily on research productivity. The likelihood that differentiated staffing will be implemented is remote--or, as one colleague stated, "The chances are slim to none."

Recommendation 3: Define the resources necessary to meet the objectives outlined in the contract and explicated in the plan of action.

The definition of resources should encompass both personnel, hardware, and physical facilities. Relative to personnel, it appears that approximately 10-15 authors (full-time equivalents) were needed to develop 300 lessons distributed among 12 basic medical science disciplines. Authors suggested that one programmer to one author was optimal. Two secretaries are needed to accommodate the demands of a Project with the number of personnel suggested by authors. One director and an associate director should be hired. The director should provide content-centered leadership to authors and facilitate development and implementation of liaison relationships. The associate director should handle the daily administration of the Project and work with the director on matters of long-range planning and maintenance of liaison relationships. Because of the instructional nature of the Project and the importance of evaluation, a full-time instructional/educational specialist, as well as a full-time evaluator, should be members of the Project staff.

Physical facilities should include a separate office per programmer-author pair. Authors noted that developing a lesson required the same concentration as preparing a journal article. Authors also suggested that a terminal in each office is needed. Work space should also be available with two or three terminals for conferences and demonstrations. Physical facilities should be proximal to student and faculty work areas to facilitate interactions among authors and these other individuals.

Recommendation 4: Special attention should be given to defining the qualifications of Project staff and hiring competent individuals.

As noted in Recommendation 3, a Project director and an associate director are needed. The director should provide academic guidance to authors and assist them in the selection of topics for lesson development. This individual should possess either an M.D. or Ph.D. degree with experience in the basic sciences, innovative education, and medical education. An understanding of clinical medicine is also needed to ensure that authors will be encouraged to

include aspects of clinical medicine in their lessons. The associate director should be skilled in the administration of educational endeavors. It would be desirable for this individual to have had previous experience within a college of medicine. This experience would help him/her understand relationships among basic science faculty, administrators, physicians, and departments. This knowledge would enable the associate director to facilitate the development of liaison relationships. Hiring a director and an associate should receive first priority. These individuals, then, would have the primary responsibility for ensuring that additional high quality staff would be acquired.

Authors should possesss a Ph.D. degree in a basic science discipline and, hopefully, have some expertise in more than one area. Authors should have had some experience in a college of medicine--preferably delivering instruction to medical students. Such experience would allow the author to have a perspective within which the instructional needs of medical students could be understood. It would also be desirable if authors had some experience in innovative instruction, either in the development or delivery of instruction. Additionally, it is essential that the author have a strong commitment to instruction and innovation in medical education and an openness to CAI as a potentially valuable medium for delivering instruction. If a competent programming staff is available, it is less important that authors have computer experience.

Relative to the programming staff, if authors are to spend the major portion of their time designing lessons, a competent programming staff is essential. Programmers should carry the burden of translating lesson designs into computerized materials. Authors felt that full-time programmers were more satisfactory than part-time graduate student programmers who were detracted frequently from their (Project) work because of academic demands. Further, authors suggested that a programmer should be assigned to each author. It was also noted that programmers should have some basic science training, as this background would help them translate lesson content into a computerized form.

A full-time instructional specialist with training (and, preferably, experience) in computer-assisted instruction should also be hired. The specialist would work with authors on the design of pre-tests, post-tests, educational objectives, and mastery learning. The specialist would also provide valuable perspectives on lesson design and instructional techniques. A full-time evaluation specialist is also needed.

Recommendation 5: The second year of Project functioning should be devoted to training staff, implementing lesson development and review procedures, and building liaison relationships.

At the beginning of the second year, all Project staff should be available for full-time participation. During this year, activities should center on intensive training and familiarization of staff with the medium, the programming language, and instructional design. It is also important that Project staff understand the contract goals and how these will be translated into action. To some extent, authors should assist the directors in formalizing the Project's plan of action. This should help authors develop a sense of ownership and increased understanding of the Project's goals.

In addition to the training of staff, Project management, with assistance from authors, evaluator, and instructional specialist, should develop and implement fully lesson development and review procedures and programming standards. It is essential that such procedures and standards exist if the product (lesson) is to be of high quality, both instructionally and scientifically. These procedures will not guarantee quality, but the probability of producing high quality lessons will be increased if such mechanisms are utilized. Lesson planning and development should include input from the instructional specialist, programmers, students, basic scientists, allied health professionals, and physician consultants. In the review phase, additional input from these participant groups is also critical. Since lessons should respond to the instructional needs of students, input from students and teaching faculty should be sought. Participation of physician consultants is encouraged because these persons can provide important insights into the correlations between the basic sciences and clinical application.

Review of lessons by content experts external to the institution where the Project is developed is important. These experts should provide feedback about the scientific integrity of lesson content, as well as the potential value of lessons to students other than those at the home institution. If lessons are to be applicable to health professions students, other than the first year basic science student, allied health professionals should be members of the expert review group. Review by faculty within the home institution is also critical because valuable information on the relationship of lessons to the non-CAI curriculum can be gained. Additionally, the accuracy of content can also be evaluated. Participation of faculty at the home institution may also increase their willingness to accept the lessons and recommend them to students.

Recommendation 6: An over-emphasis on performance-based criteria as a measure of lesson effectiveness should be discouraged when the Project is implemented in an environment where students are encouraged to use multiple learning resources.

It is difficult, if not impossible, to measure the impact of lessons on subsequent performance when students utilize a variety of learning resources in their pursuit of basic science knowledge. Other criteria of lesson effectiveness should be developed, but should include student usage of lessons. Attention might be given to measuring the value of lessons for laboratory simulation or determining how quickly students can master a concept presented via the computer as opposed to acquisition time via another medium. The belief that CAI is a form of instruction suited to all students should be discarded. No single learning resource seems to be an ideal tool for every student.

Recommendation 7: The collection of meaningful lesson usage data requires high overhead in software and programmer resources. The collection of these data should be planned for and developed at the beginning of the Project.

This recommendation really speaks to the need to plan for the evaluation of lesson effectiveness at the outset of the Project. Of course, this requires that a general evaluation strategy be developed. An evaluation specialist is needed to assist in the design and implementation of these procedures.

Relative to the evaluation of the Project, lesson usage data should be one small part of an assessment of the outcomes. Attention should be given on how the Project functions, its management programs, the qualifications of its staff, etc. A complex endeavor cannot and should not be evaluated on the basis of a single index, such as usage of lessons. Further, data from diverse groups should be gathered. Information from these individuals will offer many perspectives of the Project and its products. Formative (on-going) evaluation is essential and can provide useful information to Project personnel about weaknesses and strengths and allow personnel to take action during the Project's operation to improve the weaknesses and further strengthen successful aspects of the Project. Summative (end-product) evaluation should also be incorporated into the total evaluation plan.

Recommendation 8: Development of a network (multinodal sites) seems essential to the exportability of lessons.

Authors reported the prevalence of the attitude of faculty at other medical schools that if the lessons were not developed by those faculty, then the lessons could not possibly be of sufficient quality to permit their students to use them. Participation of faculty at other sites seems to be a reasonable method to foster the growth of feelings of lesson ownership. If these same individuals also reviewed lessons developed at other sites, then there might be less reluctance to allow students to use the lessons. Further, if the goals of the contract are substantial in scope and if the number of authors is increased via the development of multinodal sites, then it may be more likely that the goals of the contract could be attained. Additionally, having lessons developed at various sites may allow the lessons to have maximum generalizability to other curricula.

The benefits of networking as described above seem clear. However, there are several potential risks. If the network is to produce an integrated quality automated curriculum, then procedures to ensure communication among developers and enforce lesson development/review procedures must be implemented. Without such controls, the possibility exists that lessons will be redundant, disjointed, and of greatly disparate quality. Further, the implementation of an effective network requires substantial time and effort on the part of Project staff and administration.

Unresolved Issues

At least two questions remain unanswered in the evaluators' minds. The first is, "Could PLATO IV or any other educational computer system have a major role in delivering a substantial part of basic science content to first year medical students?" Will it ever be possible to eliminate or reduce the prevalence of the attitude that an educational computer system should be peripheral to the delivery of instruction to medical students, i.e., that lectures and textbooks are the only media effective for transmitting knowledge? Secondly, is it feasible to expect that basic scientists who devote their attention to the development of high quality instructional materials will be respected by their colleagues and rewarded within the university community for their contributions to instruction? Answers to these questions seem to have considerable import for the success or future of innovative instructional projects in medical education.

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